NASA TECHNICAL TRANSLATION NASA TT F-15,838

CHARACTERISTICS OF LIGHT INTENSITY FLUCTUATIONS IN A DIFFRACTION ORDER AS A FUNCTION OF THE ANGLE OF INCIDENCE OF THE LIGHT BEAM ON THE SURFACE OF AN ULTRA-SONIC LIGHT MODULATOR

V. V. Kludzin

(NASA-TT-F-15838) CHARACTERISTICS OF LIGHT INTENSITY FLUCTUATIONS IN A DIFFRACTION ORDER AS A FUNCTION OF THE ANGLE OF (Linguistic Systems, Inc., Cambridge, Mass.) 9 p HC $3.25 CSCL 20F

N75-14598

Unclas

G3/74 06132

Translation of: "Kharakteristiki izmeneniya intensivnosti sveta v difraktsionnom poryadke v zavisimosti ot ugla padeniya svetovogo potoka na poverkhnost' ul'trazvukovogo modulyatora sveta," In: Radiofizika, Vol. 17, No. 2, 1974, pp. 261-264.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 OCTOBER 1974

STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TT F-		
4. Title and Subtitle CHARACTERISTICS OF LIGHT INTENSITY FLUCTUATIONS IN A DIFFRACTION ORDER AS A FUNCTION OF THE ANGLE OF INCIDENCE OF THE LIGHT BEAM ON THE SURFACE OF AN ULTRA-SONIC LIGHT MODULATOR		5. Report Date October, 1974
		6. Performing Organization Code
7. Author(s) V. V.V. Kludzin		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address LINGUISTIC SYSTEMS, INC. 116 AUSTIN STREET CAMBRIDGE, MASSACHUSETTS 02139		11. Contract or Grant No. NASW-2482
		13. Type of Report & Period Covered TRANSLATION
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of: "Kharakteristiki izmeneniya intensivnosti sveta v difraktsionnom poryadke v zavisimosti ot ugla padeniya svetovogo potoka na poverkhnost' ul'trazvukovogo modulyatora sveta," In: Radiofizika, Vol. 17, No. 2, 1974, pp. 261-264. (A74-26091)

16. Abstract

17. Key Words (Selected by Author(s))	18. Distribution Statement
	UNCLASSIFIED - UNLIMITED

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

PRECEDING PAGE BLANK NOT FILMED

CHARACTERISTICS OF LIGHT INTENSITY FLUCTUATIONS IN A DIFFRACTION ORDER AS A FUNCTION OF THE ANGLE OF INCIDENCE OF THE LIGHT BEAM ON THE SURFACE OF AN ULTRA-SONIC LIGHT MODULATOR

V. V. Kludzin

ABSTRACT

The experimental characteristics of the light intensity distribution in a Bragg diffraction order are presented as a function of the angle of incidence of the light beam on the surface of a delay line in the presence of "nonresonance" of ultrasonic wave excitation in lithium niobate monocrystals in the frequency range 300-700 Mc/S. /261*

One of the characteristics of an ultrasonic light modulator, operating in a state of Bragg diffraction, is the characteristic of light intensity distribution in a working diffraction order as a function of the angle of incidence of the light beam on the surface of a light modulator. This characteristic permits us to make judgments about those limitations which the geometry of the Bragg diffraction introduces in the transmission band of the light modulator, and also about the character and magnitudes of variation of the amplitude of the ultrasonic signal with respect to the length of the delay line.

For the investigation of light diffraction in ultrasonic waves in the presence of "nonresonance" of their excitation [1, 2], the dependencies of the light intensity variation in th diffraction order on the angle of incidence of the light beam are used to determine the transmission band width of the acoustical optical device. Knowledge of these characteristics proves especially important in the presence of "nonresonance" of ultrasonic wave excitation in piezoelectric crystals by means of planar delaying structures [2, 3].

---

* Numbers in the margin indicate pagination in the foreign text.

The character of the dependence of light intensity in the diffraction order on the angle of incidence of the light beam on the surface of the delay line of the light modulator is determined by the expression [4, 5]

$$\frac{I_1(\theta)}{I_0} \sim \left\{ \int_{-\infty}^{\infty} \gamma(y) \exp[-ik(\theta-\theta_B)y]dy \right\}^2,$$

where I_1 / I_0 is the ratio of light intensity in the first and zeroth diffraction orders; $\gamma(y) = \frac{\pi}{\lambda_\ell \cos\theta} \frac{\Delta\varepsilon(y)}{\varepsilon_0}$ is a function characterizing the ultrasonic amplitude distribution in the direction y; $k = 2\pi/\lambda_s$ is the wave number of the ultrasonic wave; $\theta_s = \lambda_\ell/2\lambda_s$ is the Bragg angle; λ_ℓ is the length of the light wave; ε_0 is the dielectric constant within the acoustic-optical ineraction; $\Delta\varepsilon$ is the change in the dielectric constant induced by the presence of the ultrasonic wave.

This expression can be generalized and represented in the form /262

$$\frac{I_1(\Delta)}{I_0} \sim \left\{ \int_{-\infty}^{\infty} \gamma(y) \exp(-i\Delta y)dy \right\}^2,$$

$$\Delta = \Delta(k\theta) = 2\pi\Delta\left(\frac{f}{v}\theta\right).$$

v is the velocity of the ultrasonic wave; f is the ultrasonic signal frequency; the symbol Δ indicates a small increment in each of the variables in parentheses (f, θ, v).

In this way, the light intensity distribution in a Bragg diffraction order, as a function of the parameter Δ, is the square of the Fourier transform of the ultrasonic amplitude distribution along the direction y [4, 5].

In keeping with [1, 2] the "nonresonant" method of ultrasonic wave excitation does not limit the acoustic transmission band of the device. Measuring the light intensity in the diffraction order in the presence of variation in the angle of incidence of the light beam on the surface of a delay line, it is possible to determine the character of the ultrasonic signal amplitude along the excitation surface. In addition to this, using the expression

$$\Delta f = \frac{2 n_0 v}{\lambda} \Delta\theta,$$

where n_0 is the refractive index in the acoustic-optical interaction; this characteristic can be rewritten as a relation which is an "optical" amplitude-frequency characteristic of the device.

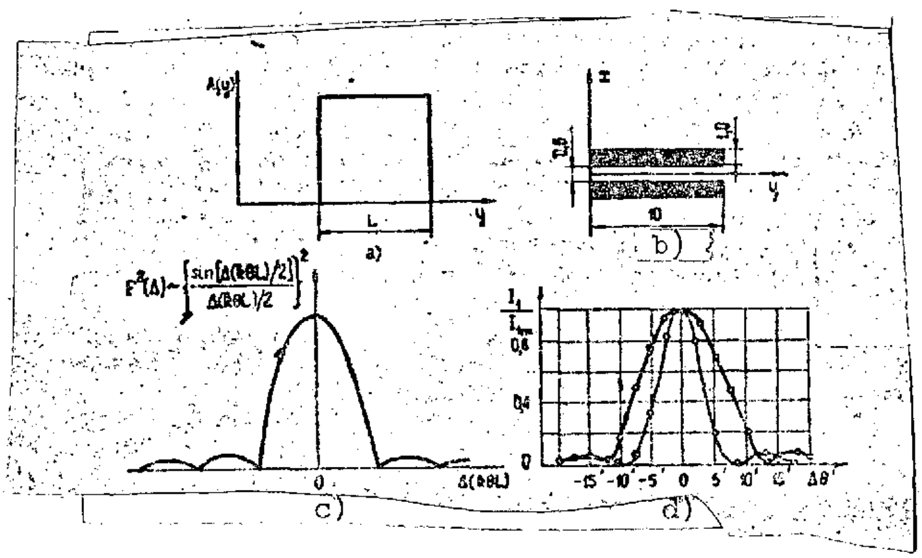

Figure 1. a) Approximated ultrasonic amplitude distribution; b) configuration of the planar exciting structure; c) theoretical form of the square of the Fourier transform of the given distribution; d) experimental characteristics.

——— - 300 MHz; ——— - 500 MHz.

Experimental investigations have been conducted using monodomain lithium niobate crystals and planar exciting structures, the configuration of which is shown in Figs. 1 - 3. The LG-36

helium-neon laser, the FEU-27 photomultiplier and standard source radio signals were used in the investigation plan. At entry, a radio impulse, of duration 2-5 μs and power not more than 0.5 W, /263
is supplied to the exciting planar structure. An ultrasonic wave is disseminated in the direction of the optical axis (the Z axis) of the lithium niobate monocrystal.

The experimental characteristics were noted in the presence of longitudinal and displacement wave excitation. In Fig. 1 are shown the characteristics of light intensity variation in a diffraction grating as a function of angle of incidence θ of the light to the delay line surface during longitudinal ultrasonic wave excitation in a Z-cut lithium niobate monocrystal. The dimensions and configuration of the exciting grid are shown in Fig. 1b. Measurements were taken at frequencies of 300 and 600 Mc/S.

The theoretical form of the characteristic for the given ultrasonic amplitude distribution (Fig. 1a) has the form as a function

$$\left[\frac{\sin\frac{1}{2}\Delta(k\theta L)}{\frac{1}{2}\Delta(k\theta L)}\right]^2,$$

where L is the length of acoustic-optical interaction in the direction of the Y axis (Fig. 1c).

The irregularity of the ultrasonic field distribution along the width of the modulator (along the direction of Y) leads to an increase of the principal maximum and a decrease of the lateral maximum (Fig. 1d). Represented in Figures 2, 3 are analogous characteristics of devices in which multi-element exciting structures are used; moreover, in these cases the ultrasonic displacement waves are excited.

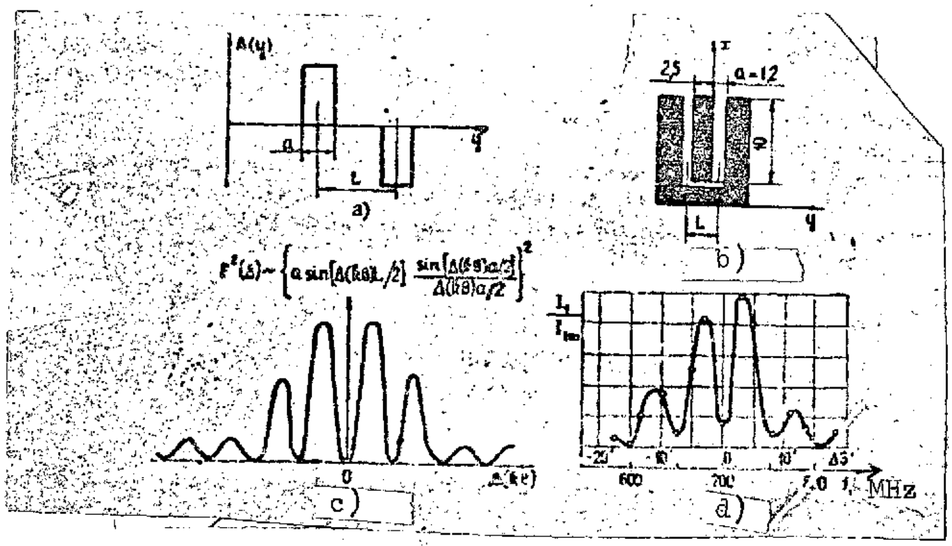

Figure 2. a) Approximated ultrasonic amplitude distribution; b) configuration of planar exciting structure; c) theoretical form of the square of the Fourier transform of the given distribution; d) experimental characteristics, f_0 = 700 MHz.

The distributions of ultrasonic amplitudes A(Y) for the presented configurations of planar exciting structures can be approximated in the form shown in Figs. 2a, 3a. Negative values of the approximation A(y) (Figs. 2a, 3a) indicate phase shift between adjacent emitters at π. In Figs. 1c, 2c the squares of the Fourier transform F(Δ) are presented for corresponding approximations of ultrasonic amplitude distribution A(y). Light wave dissemination occurs in all cases along the y axis (Figs. 1-3). The difference in the experimental curves from the theoretical is accounted for by the non-uniform electric contact between the planar structure and the exciting surface of the piezoelectric crystal, and also by the finite length of the light beam diameter. In Figs. 2d, 3c the lower axis of the abscissa corresponds to the /264 transferred frequency scale, and the derived functions correspond to the amplitude-frequency characteristics.

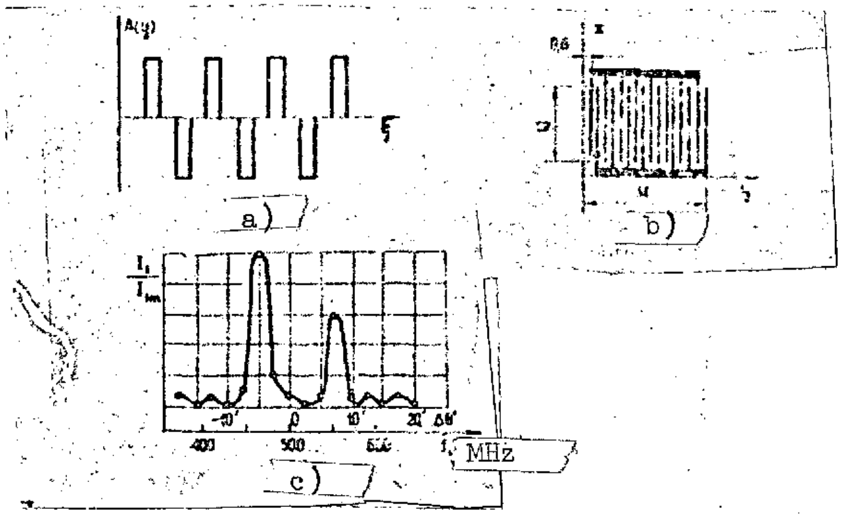

Figure 3. a) Approximated ultrasonic amplitude distribution; b) configuration of the planar exciting structure; c) experimental characteristics, f_0 = 500 MHz.

In measuring amplitude-frequency characteristics of wideband acoustic optical devices, especially in the UHF range, matching, over a wide band width, of the electronic circuits which feed the ultrasonic modulator is necessary and also a precise measurement of the level of UHF signal supplied to the planar structure.

The implementation of these problems presents practical difficulties, whereas the described method of measuring the light intensity distribution in a diffraction order permits us to carry out the measurement at one frequency, i.e., it does not require matching in a wide band of frequencies and the measurement of the level of UHF signal, which naturally simplifies the process of finding amplitude frequency characteristics of wideband ultrasonic light modulators.

Leningrad Institute of
Aviation Instrument Building.

Submitted
April 23, 1973

Literature

1. H. E. Bömmel, K. Dransfeld, Phys. Rev., 117, No. 3, 1245 (1960)
2. E. M. Ganopol'skiy, A. I. Chernets, Report of the AN SSR, 149, No. 1, 72 (1963).
3. V. V. Kludzin, Works of Leningrad Institute of Aircraft Manufacture, Issue 75, 133 (1972)
4. M. G. Cohen, E. J. Gordon, Bell. Syst. Techn. J., 44, No. 4, 693 (1965).
5. C. F. Quate, C. D. Wilkinson, D. K. Winslow, Proc. IEEE, 53, No. 10, 1604 (1965)